10/533890
Rec'd PCT/PTO 05 MAY 2005
PCT/E[illegible]3/50747
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Patentanmeldung Nr.	Patent application No.	Demande de brevet n°

02079711.4

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Office européen des brevets

Anmeldung Nr:
Application no.: 02079711.4
Demande no:

Anmeldetag:
Date of filing: 05.11.02
Date de dépôt:

Anmelder/Applicant(s)/Demandeur(s):

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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
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Si aucun titre n'est indiqué se referer à la description.)

An infra-red reflecting layered structure

In Anspruch genommene Prioriät(en) / Priority(ies) claimed /Priorité(s) revendiquée(s)
Staat/Tag/Aktenzeichen/State/Date/File no./Pays/Date/Numéro de dépôt:

Internationale Patentklassifikation/International Patent Classification/ Classification internationale des brevets:

G02B5/00

Am Anmeldetag benannte Vertragstaaten/Contracting states designated at date of filing/Etats contractants désignées lors du dépôt:

AT BE BG CH CY CZ DE DK EE ES FI FR GB GR IE IT LI LU MC NL PT SE SK TR

Field of the invention.

The invention relates to an infra-red reflecting layered structure and to the use of such a layered structure as heat-mirror.

Background of the invention.

Heat-mirrors that reflect radiation in the infrared spectrum while transmitting radiation in the visible spectrum have important applications for example as windows in buildings or vehicles.

For transparent heat-mirrors, visual light transmission must be high, and hence the reflectivity and absorptivity must be low.
In the United States of America for example, automotive windshields must have a transmission of visible light of at least 70%.
In the infrared, however, the heat-mirror must have high reflectivity and so transmission and absorptivity in the infra-red must be low.

Heat-mirrors comprising a stack of alternating dielectric and metal layers are known in the art.
To obtain a heat-mirror characterised by a low heat transmission, generally at least three metal layers are necessary. However, the number and the thickness of the metal layers have a negative influence on the visual light transmission.

It is well known to use silver as metal layer. However, a silver layer has a low stability, low durability and poor moisture and weather resistance.

Summary of the invention.

It is an object of the present invention to provide an improved infra-red reflecting layered structure.

It is another object to provide an infra-red reflecting layered structure characterised by a good visual light transmission and a low solar heat gain coefficient with a minimum number of metal layers.

It is a further object of the invention to provide an infra-red reflecting layered structure having silver containing layers with a high stability and a high weather resistance.

According to a first aspect of the present invention an infra-red reflecting layered structure is provided. The layered structure comprises :

- a transparent substrate layer;
- a first metal oxide layer;
- a first silver containing layer;
- a second metal oxide layer;
- a second silver containing layer and
- a third metal oxide layer.

The first, second and third metal oxide layer have a refractive index of at least 2.40 at a wavelength of 500 nm.

The layered structure according to the present invention has a visual light transmittance (VLT) higher than 70 % and a solar heat gain coefficient (SHGC) lower than 0.44.
The light to solar gain ratio (LSG ratio) of the layered structure is preferably higher than 1.60. More preferably, the LSG ration is higher than 1.65, for example 1.69.

The visual light transmission (VLT) refers to the percentage of the visible spectrum (380 –720 nanometers) that is transmitted through a window.

The solar heat gain coefficient (SHGC) is the fraction of incident solar radiation admitted through a window, both directly transmitted and absorbed and subsequently released inward. SHGC is expressed as a number between 0 and 1. The lower a window's solar heat gain coefficient, the less solar heat it transmits.

The light to solar gain ratio (LSG ratio) is defined as $\frac{VLT}{SHGC * 100}$. The LSG ratio provides a gauge of the relative efficiency of different glass types in transmitting daylight while blocking heat gains. The higher the ratio, the brighter the room is without adding excessive amounts of heat.

A preferred metal oxide layer comprises TiO_2. TiO_2 having a refractive index of 2.40 is mainly composed of rutile phase and is very dense. A TiO_2 layer can be deposited by a reactive sputter deposition process from a Ti-target, a TiO_2-target or a substoichiometric TiO_x-target (with x between 1.75 and 2).

Other metal oxides having a high refractive index are for example BiO_2 (refractive index 2.45 at 550 nm) or PbO (refractive index 2.65 at 550 nm).

The metal oxide layers of the layered structure can be deposited by any technique known in the art. Preferred techniques comprise physical vapor deposition techniques such as sputter deposition or chemical vapor deposition techniques.

The different metal oxide layers of the layered structure may comprise the same material or may comprise a different material.

The first and second silver containing layers may comprise pure silver (i.e. silver with unavoidable impurities) or silver in combination with another element as for example gold, platinum, palladium, copper, aluminium, indium or zinc and/or mixtures thereof.

The silver containing layers comprise for example silver and up to 30 wt% of another element such as gold, platinum, palladium, copper, aluminium, indium or zinc and/or mixtures thereof.

A preferred silver containing layer comprises 10 wt % gold.

The silver containing layers are preferably deposited by a vacuum deposition technique, for example by sputtering or evaporation.

To increase the stability and durability of the silver containing layer, it can be preferred that an intermediate layer is deposited between a metal oxide layer and a silver containing layer; between a silver containing layer and a metal oxide layer or that an intermediate layer is deposited on both sides of a silver containing layer.

Such an intermediate layer preferably comprises gold, for example pure gold (i.e. gold with unavoidable impurities) or gold in combination with for up to 30 wt% of another element such as silver.

The intermediate layer has preferably a thickness between 0.5 and 10 nm, for example 1 nm.

Preferably, an intermediate layer is deposited by sputter deposition.

The layered structure according to the present invention comprises at least one transparent substrate layer.

The transparent substrate layer or layers may comprise a glass layer or a plastic layer for example a plastic layer made of polycarbonate, polyacrylate, polyester such as polyethylene terephtalate or polyurethane.

Possibly, an additional layer is deposited on top of the layered structure. Such an additional layer comprises for example a protective layer or an abrasion resistant layer.

According to a second aspect the use of an infra-red reflecting layered structure as a transparent heat-mirror is provided.

Brief description of the drawings.

The invention will now be described into more detail with reference to the accompanying drawings wherein

- Figure 1, 2 and 3 show different embodiments of an infra-red reflecting layered structure according to the present invention.
- Figure 4 shows the transmittance of a layered structure according to the present invention.
- Figure 5 shows the cross-section of a spectrally selective solar control window film.
- Figure 6 shows the cross-section of an automotive glazing comprising a layered structure according to the present invention.

Description of the preferred embodiments of the invention.

An embodiment of an infra-red reflecting layered structure 10 is shown in Figure 1. The layered structure comprises three metal oxide layers 12, 14, 16 and two silver containing layers 13,15.

The metal oxide layers comprise TiO_2 having a refractive index of 2.40 at 500 nm.

The silver containing layers 12, 14 comprise pure silver (i.e. silver with unavoidable impurities).

In an alternative embodiment the silver containing layers 12, 14 comprise a silver layer comprising 10 wt% gold.

The first metal oxide layer 12 and the third metal oxide layer 16 have a thickness ranging between 25 and 35 nm.

The second metal oxide layer has a thickness between 50 and 70 nm.

The first and second silver containing layer 13, 15 have a thickness between 10 and 25 nm.

The infra-red reflecting layered structure according to the present invention combines a high visual light transmittance (VLT) with a low solar heat gain coefficient (SHGC).

Infra-red reflecting layered structures known in the art need three silver containing layers to obtain the desired low solar heat gain coefficient. The layered structures according to the present invention have a low solar heat gain coefficient with only two silver containing layers. This has a positive influence on the visual light transmittance.

Figure 2 shows another embodiment of an infra-red reflecting layered structure 20. The layered structure is the same as the layered structure shown in Figure 1 but additionally comprises intermediate layers 27, 27', respectively between the first metal oxide layer 22 and the first silver containing layer 23 and between the second metal oxide layer 24 and the second silver containing layer 25.
The intermediate layers comprise gold and have a thickness of 1 nm.

Figure 3 shows a further embodiment of an infra-red reflecting layered structure 30. Intermediate layers 37, 37' and 39, 39' are deposited on both sides of the silver containing metal layers 33, 35.
The intermediate layers comprise gold or gold comprising 10 wt% silver.

The intermediate layers have a thickness of 1 nm.

The intermediate layers increase the stability and durability of the silver containing layers.

Figure 5 shows the cross-section of a spectrally selective solar control window film 50 comprising :

- a hard coat top layer 52 for example comprising a cross-linked acrylic;
- a first PET film 53 having a thickness of for example 23 μm;
- a layered structure 54 according to the present invention;
- a first adhesive layer 55;
- a second PET film 56 having a thickness of for example 23 μm;

- a second adhesive layer 57;
- a glass layer 58.

Figure 5 shows the sequence of the different layers. The thickness of the different layers is not in proportion to the real thickness.

The optical properties of the spectrally selective solar control window shown in Figure 5 are given in Table 1.

Table 1

Visual properties		
VLT	Visual Light Transmittance (%)	71
VLR	Visual Light Reflectance (%)	9
Solar Properties		
SHGC	Solar Heat Gain Coefficient	0.42
TSER	Total Solar Energy Reflected (%)	58
LSG ratio	light-to-solar-gain ratio	1.69
UV properties		
TUV	UV Transmittance (%)	< 0.2

The transmittance T (expressed in %) of the spectrally selective solar control as shown in Figure 5 is given in Figure 4 for the UV, visible and near infra-red.

Figure 6 shows the cross-section of an automotive glazing comprising :

- a first glass layer 62;
- a first adhesive layer 63 for example comprising a PVB layer having a thickness of 375 µm;
- a PET film 64 having a thickness of for example 50 µm;
- a layered structure 65 according to the present invention;

- a second adhesive layer 66 for example comprising a PVB layer having a thickness of 375 µm;
- a glass layer 67.

CLAIMS

1. An infra-red reflecting layered structure, said layered structure comprising
   - a transparent substrate layer;
   - a first metal oxide layer;
   - a first silver containing layer;
   - a second metal oxide layer;
   - a second silver containing layer;
   - a third metal oxide layer;

   said first, second and third metal oxide layer having a refractive index of at least 2.40 at a wavelength of 500 nm and said layered structure having a visual light transmittance (VLT) higher than 70 % and a solar heat gain coefficient (SHGC) lower than 0.44.

2. A layered structure according to claim 1, whereby said layered structure has a light to solar gain ratio (LSG ratio) higher than 1.60.

3. A layered structure according to claim 1 or claim 2, whereby said metal oxide layer comprises TiO_2.

4. A layered structure according to claim 3, whereby said TiO_2 .is mainly composed of rutile phase.

5. A layered structure according to any one of the preceding claims, whereby said layered structure comprises at least one intermediate layer, said intermediate layer being located between a silver containing layer and a metal oxide layer or between a metal oxide layer and a silver containing layer.

6. A layered structure according to claim 5, whereby said intermediate layer comprises gold.

7. A layered structure according to any one of the preceding claims, whereby said first and second silver containing layer have a thickness between 10 and 25 nm.

8. A layered structure according to any one of the preceding claims, whereby said first, second and third metal oxide layer have a thickness between 25 and 70 nm.

9. Use of a layered structure according to any one of claims 1 to 8 as a transparent heat-mirror.

ABSTRACT

The invention relates to an infra-red reflecting layered structure comprising a transparent substrate layer; a first metal oxide layer; a first silver containing layer; a second metal oxide layer; a second silver containing layer and a third metal oxide layer

The first, second and third metal oxide layer have a refractive index of at least 2.40 at a wavelength of 500 nm.

The layered structure according to the present invention has a visual light transmittance (VLT) higher than 70 % and a solar heat gain coefficient (SHGC) lower than 0.44.

The invention further relates to the use of a layered structure as a transparent heat-mirror.

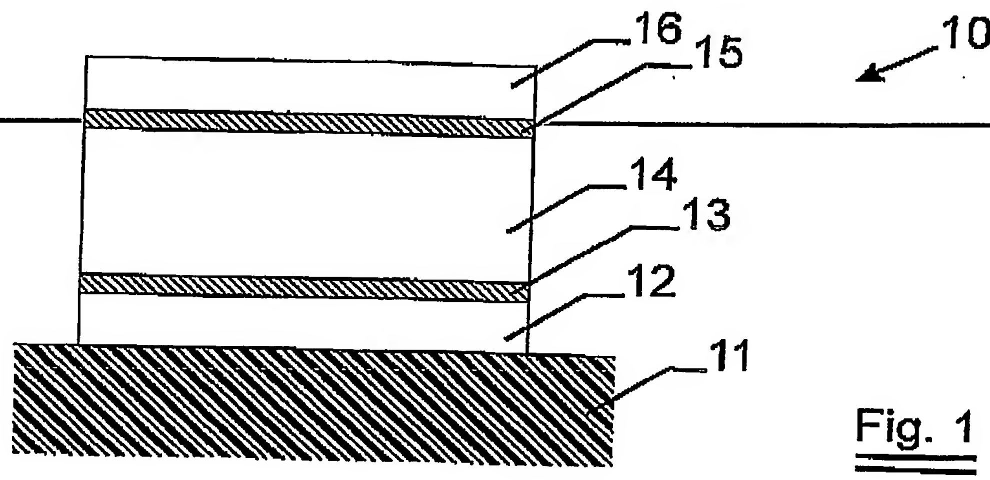

Fig. 1

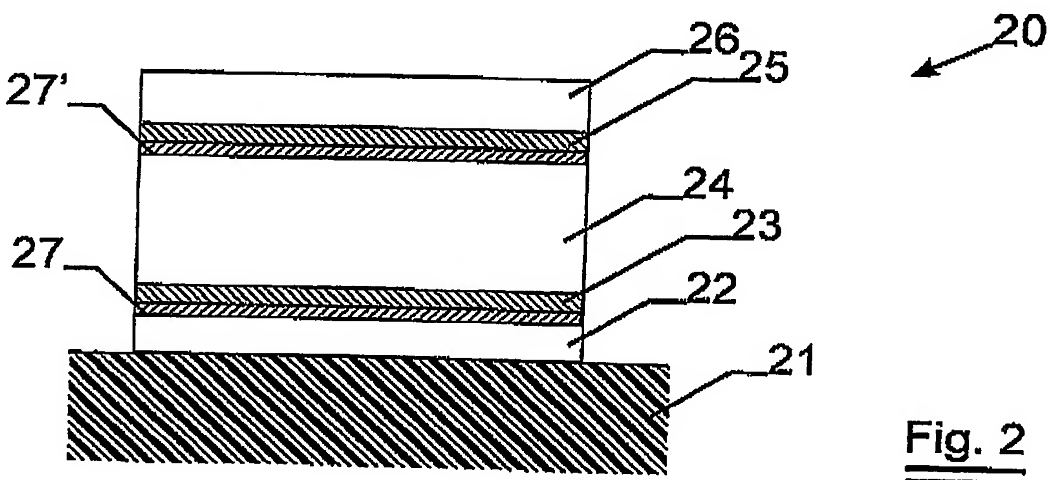

Fig. 2

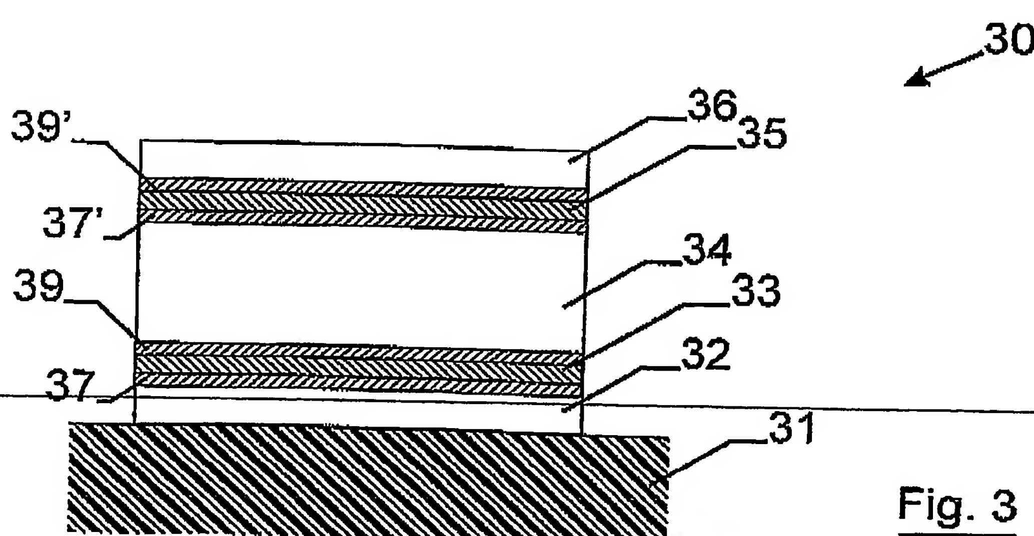

Fig. 3

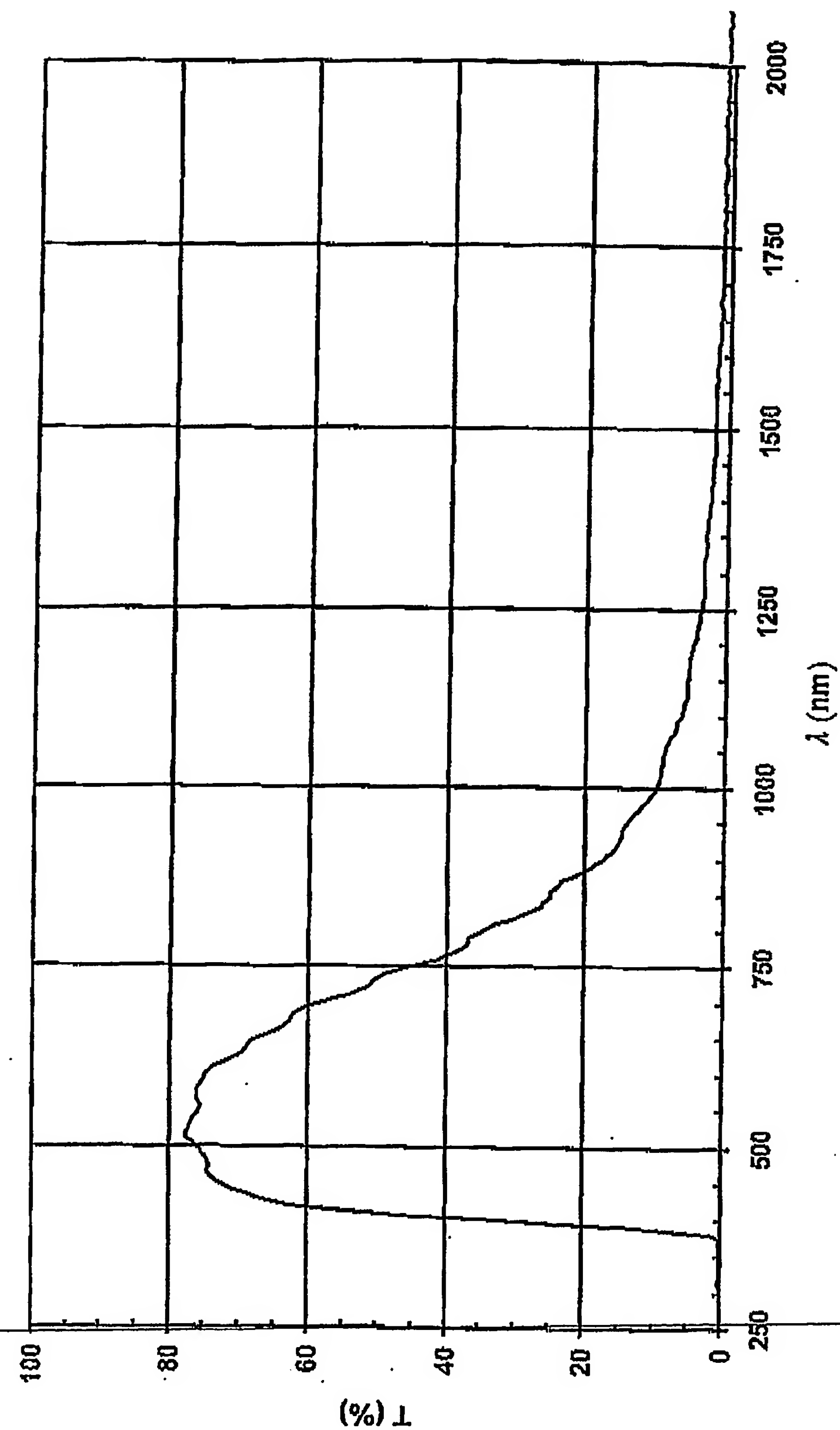

Fig. 4

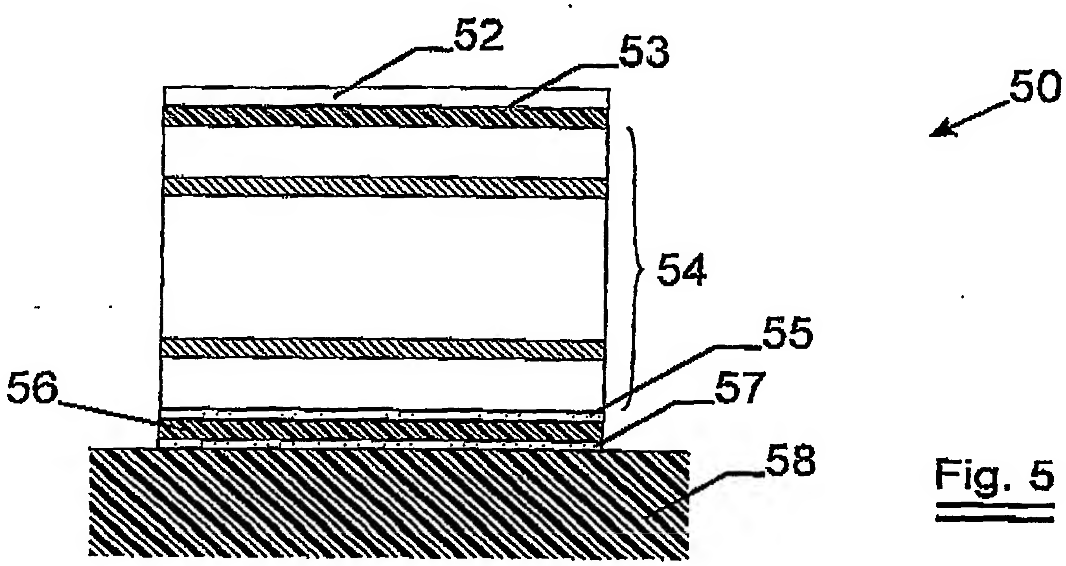

Fig. 5

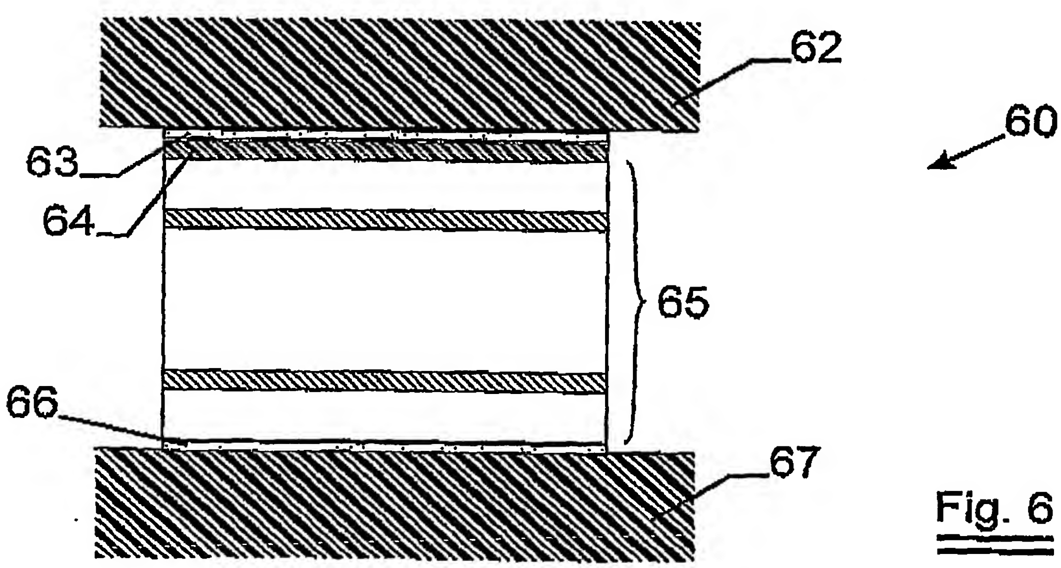

Fig. 6